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DEPARTEMENT COMPUTERWETENSCHAPPEN
AFDELING NUMERIEKE ANALYSE EN
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Celestijnenlaan 200A – B-3001 Heverlee

WAVELETS: SOFTWARE AND APPLICATIONS

Promotoren:
Prof. Dr. ir. D. Roose
Prof. Dr. A. Bultheel

Proefschrift voorgedragen tot
het behalen van het doctoraat
in de toegepaste wetenschappen

door

Geert UYTTERHOEVEN

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Jury:
Prof. Dr. ir. R. Govaerts, voorzitter
Prof. Dr. ir. D. Roose, promotor
Prof. Dr. A. Bultheel, promotor
Prof. Dr. ir. B. De Moor
Prof. Dr. ir. R. Cools
Prof. Dr. J.-P. Antoine
(Université catholique de Louvain)

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Wavelets: Software and Applications

Geert Uytterhoeven
Department of Computer Science, K.U.Leuven
Celestijnenlaan 200A, B-3001 Heverlee, Belgium

Abstract

During the last decade, the wavelet transform has proven to be a valuable tool in many application fields. In this thesis we focus on two applications: image processing and compression to create low-dimensional models for dynamical systems.

We worked out the details of integer wavelet transforms, based on the lifting scheme, for a class of biorthogonal wavelets (Cohen-Daubechies-Feauveau). Based on this we designed and implemented a software library called *WAILI* (Wavelets with Integer Lifting) that provides wavelet transforms and wavelet-based image processing operations on two-dimensional images. Later we added support for very large images and block-based processing.

We created a new kind of second-generation wavelets on a rectangular grid, based on a red-black blocking scheme. These Red-Black wavelets are less anisotropic than tensor product wavelets.

We reduced the complexity of the Proper Orthogonal Decomposition (POD) by biorthogonal wavelet packet compression and evaluated the resulting Approximate POD by analyzing a large-scale dynamical system, described by partial differential equations.

Preface

My first contacts with wavelets were in 1993, when I started working on my Master's Thesis about compression using multi-wavelets, under supervision of Prof. Adhemar Bultheel, with Wim Sweldens as daily advisor. After I finished my thesis, Wim Sweldens and Prof. Björn Jawerth gave me the opportunity to visit the Department of Mathematics at the University of South Carolina for one month, where I continued the work that I started with my thesis.

In September 1994 I joined the Scientific Computing Research Group of the Department of Computer Science at K.U.Leuven, under the direction of Prof. Dirk Roose, where wavelet research is done in collaboration with Prof. Adhemar Bultheel of the Numerical Approximation and Linear Algebra Group of the same department. I want to thank both for becoming the advisors for my Ph.D. Thesis.

My first research topic was wavelet-based compression to create low-dimensional models for dynamical systems. After about 1.5 years I went back to the area of image processing, thanks to the Flemish Information Technology Action Program.

Within the K.U.Leuven wavelet team, I enjoyed working together with Maurits Malfait and Maarten Jansen (wavelet-based noise reduction) and Filip Van Wulpen (development of WAILI). At the Department of Computer Science, there lives an open and pleasant atmosphere, and I had lots of interesting discussions with colleagues.

I kept in touch with Wim Sweldens and his wife Kirsten Schulz, who were generous in their hospitality when I visited the United States.

I would like to thank Prof. Bart De Moor for being a member of the reading committee, and Prof. René Govaerts, Prof. Ronald Cools and Prof. Jean-Pierre Antoine for being members of the jury.

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Last but not least, I owe a lot to my parents, who gave me the opportunity to study, and to my sisters Inge and Katrien, who always supported me during the previous years. Also I want to thank my friends in and near (the world is getting smaller :-) the city of Leuven for the great times we had together.

Geert Uytterhoeven
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